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Introduction to the DTS 3.5 Object Model

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Agenda

- Terminology Overview
- DTS Overview
- DTS Data Model

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Overview

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What is a Structured Terminology?

- A structured terminology is composed of *concepts* along with *synonymous terms*, *properties* and various relationships
- *Relationships*
  - Taxonomy (is-a)
  - Partonomy (part-of)
  - Etiology (caused-by)
  - Therapy (treated-by)
  - …

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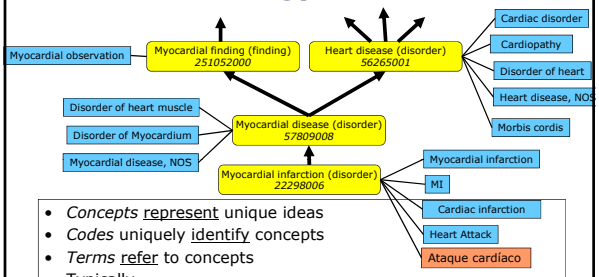
Terminology Elements



- *Concepts* represent unique ideas
- *Codes* uniquely identify concepts
- *Terms* refer to concepts
- Typically
  - Humans communicate concepts using terms
  - Computers communicate concepts using codes
- Concepts are language independent; terms are dependent

Interplay among Terminology Elements

- Humans and computers
  - select, apply and transform
    - concepts, codes and terms
  - Across human languages
  - Across contexts (geographic, medical specialty, etc.)
  - Across applications
- Example scenario
  1. English *term* entered by clinician
  2. *Term* is encoded in SNOMED
  3. *Code* is recorded in Electronic Health *Record*
  4. *Record* is retrieved
  5. *Record* is transmitted to another application (perhaps in another institution)
  6. *Code* is extracted
  7. *Term* is requested by a nurse, e.g.,
     - Spanish term
     - Consumer term
     - Spanish consumer term
  8. *Term* is displayed

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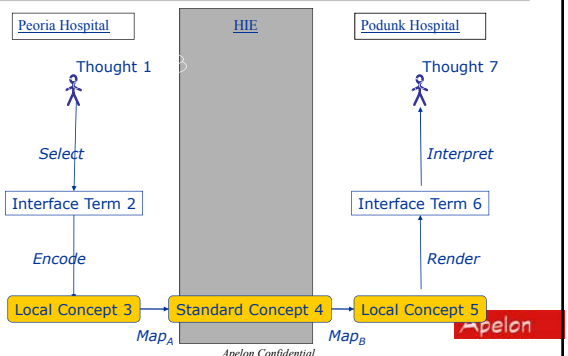
Common Understanding



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Why Standard Terminology?

- Provide *consistent meaning*
- Promote *shared understanding*
- Facilitate *communication* with humans
- Enable *comparison* and *integration* of data
- Essential for *interoperation* among systems, applications and institutions
- Crucial for Electronic Health Record (EHR) *sharing* and *portability*
  - Health Information Exchange (HIE)
  - National Health Information Network (NHIN)

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Significant Applications

- Structured terminologies are needed in healthcare for
  - Reimbursement
  - Data integration
  - Decision support
  - Clinical guidelines
  - Medical error reduction
  - Clinical trials
  - Public health surveillance

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Standard Terminologies

- Clinical (SNOMED CT)
- Reimbursement (ICD, CPT, HCPCS)
- Pharmaceuticals (RxNorm, NDF-RT …)
- Labs (LOINC)
- Nursing (ICNP, NIC, NOC, NANDA)
- Adverse events (MedDRA, COSTART, WHOART)
- Genetics (GO)
- …

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What is DTS?

- An enterprise vocabulary server used to :
  - Acquire & maintain standards
  - Integrate and manage local code sets
  - Map/interrelate terminologies
  - Deploy in applications
- Originally developed as an Apelon commercial product, but now open source

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What Is a Terminology Server?

- A Terminology Server is:
  - a networked, software component
  - that centralizes terminology knowledge (e.g. national and international standards)
  - and provides *terminology services* to other network applications.

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Terminology Servers

- Terminology Servers are used:
  - By *informaticians* to create, extend, localize, and map terminologies
  - By *interface applications* to translate data elements between applications
  - By *clinical applications* to select and standardize data input

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Examples of Terminology Services

- Term/name normalization:
  What is SNOMED CT name for "heart attack"? ***Myocardial Infarction***
- Code translation
  What is the ICD-9 code for *Myocardial Infarction?* **410.9**
- Grouping and aggregation
  Is *Myocardial Infarction* a *Cardiac Disease*? **Yes**
- Clinical knowledge
  What drug treats *Myocardial Infraction*? **Streptokinase**
- Local information
  Add L227 as the local code for *Serum Calcium*. **Okay**

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DTS Components

- Knowledge Base (Content)
- Server
- Client API
- GUI applications
- Utilities and samples
- Subscription content service
- Professional support

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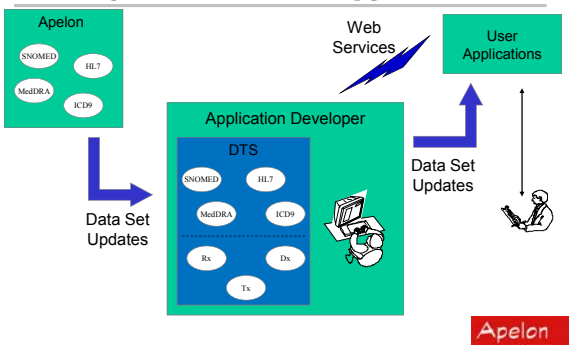
Apelon Terminology Model



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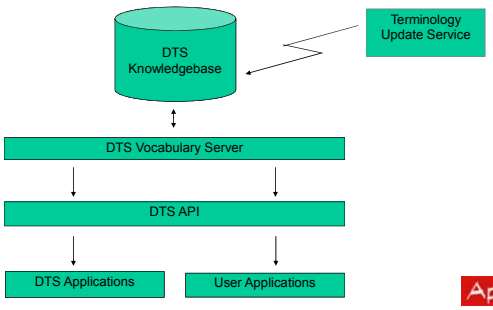
DTS Components



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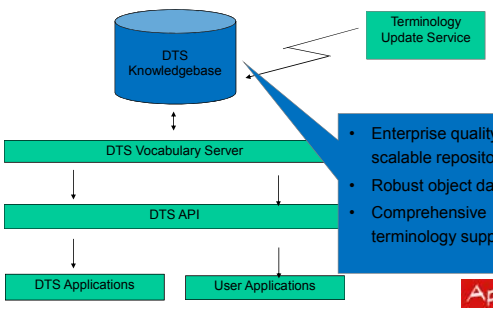
DTS Components



- Enterprise quality, highly scalable repository
- Robust object data model
- Comprehensive terminology support

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DTS Knowledgebase

- Clinical framework (SNOMED CT)
- Reimbursement code sets w/mappings: ICD, CPT, HCPCS
- Multum and NDF-RT drug terminology and classification systems
- Nursing sets: NIC, NOC, and NANDA
- Adverse event terminologies MedDRA, COSTART, WHOART
- Mappings to MeSH and UMLS CUIs
- Apelon's Consumer Health Vocabulary (mappings to SCT)
- Extensible with local additions

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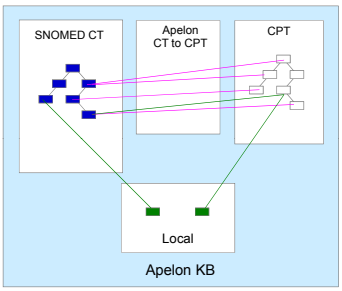
Apelon KB Architecture

Subscription Namespaces

- Derived from industry sources
- Provided by Apelon
- "Read only" in DTS

Local Namespaces

- Customer-specific data
  - Concepts
  - Properties
  - Associations (mappings)
  - Code and Value sets
- Protected during updates



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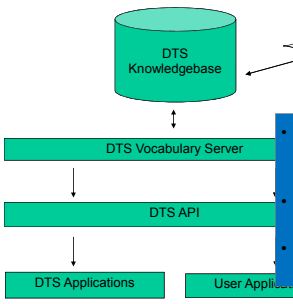
DTS Components



- "Subscription" access to industry standard terminologies and thesauri
- Web downloadable differential updates
- Local content protected during updates

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Terminology Update Service

- Subscription-based access to standard terminologies
- Simplifies terminology acquisition and management
  - Multiple data sources
  - Multiple (changing) data formats
  - Varying update frequencies
- Saves management time and development resources
- Maintains integrity of customer content and mappings
- Easy updating with exception reporting

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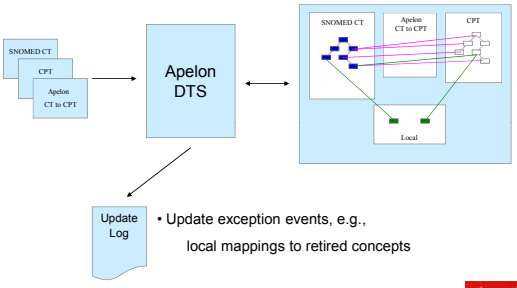
Subscription Update Process



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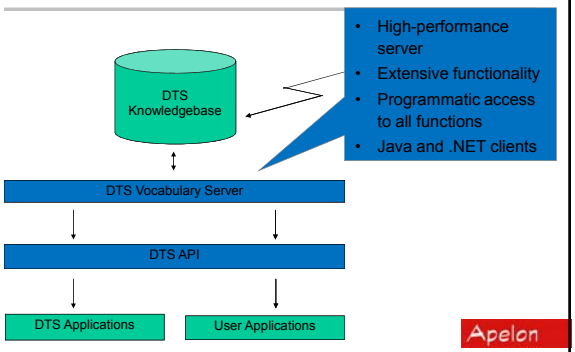
DTS Components



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DTS Server

- Programmatic interface to terminology data
- Scalable, high-performance architecture
- Built on industry standard platforms:
  - Windows, J2EE, Oracle, .NET, SQL Server
- API (Java/.NET) provides access to all terminology functions

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DTS Functionality

- API Services:
  - Search (w/spelling correction, stemming, contexts, etc.)
  - Navigation and code translation
  - Subsetting
  - Class/subsumption query
  - Localization
- Performance features:
  - Connection pooling
  - Concept caching
  - Multi-concept (batch) requests

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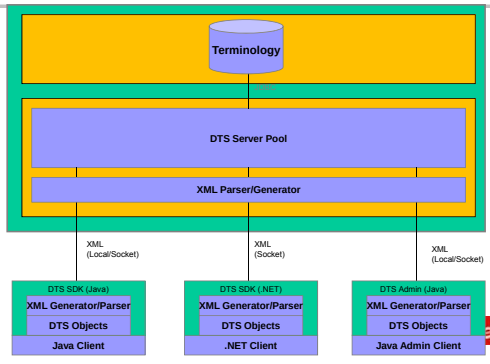
DTS Server Architecture



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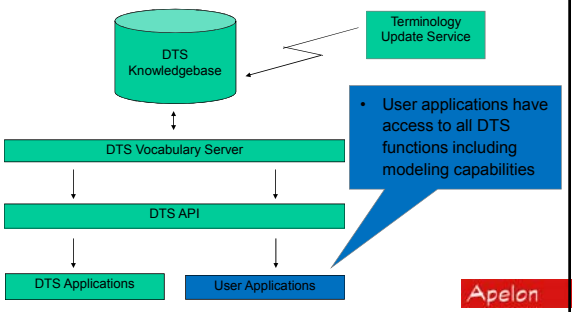
DTS Components



- User applications have access to all DTS functions including modeling capabilities

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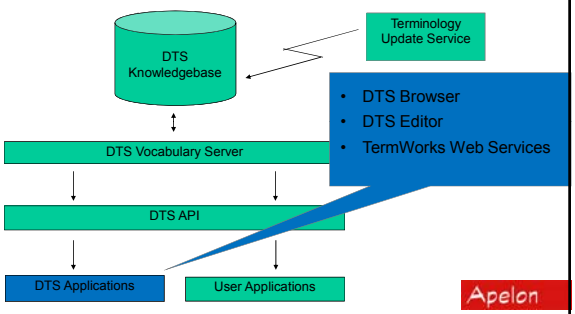
DTS Components



- DTS Browser
- DTS Editor
- TermWorks Web Services

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Data Model

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Objective

Understand the basic Data Model used to represent terminology information in the Apelon Knowledge Base.

This understanding is a prerequisite for both content browsers, modelers and programmers using DTS.

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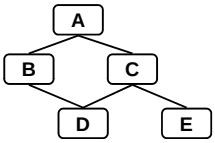
Background: *Hierarchy*



- **A** is the *parent* of B and C
- **D** is a *child* of B and C
- **A** is an *ancestor* of all the other concepts
- **E** is a *descendant* of **A** and **C**
- **A** is the *root*
- **D** and **E** are *leaves*

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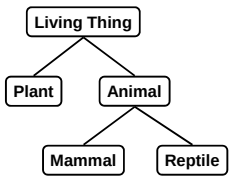
Background: *Taxonomy*

- Generalization ("is-a") hierarchy
- Composed of concepts (ideas)
- Parents are more general than children
- Thus, ancestors are more general than descendants
- Root(s) are the most general concept(s)



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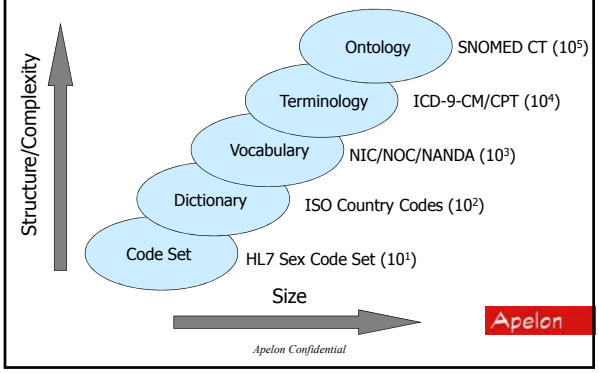
Nomenclatures



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Data Model

- Crucial for understanding how to use DTS
- Today
  - Quick graphical overview
  - Outline of further details
- Caveats
  - Simplified view
  - Reflects Browser and Editor
  - API is more involved

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Background: UML Class Diagrams

- Classes
  - Name
  - Attributes
  - …
- Associations *
  - Name
  - Roles *
  - Cardinality
  - …
- …

* UML *roles* and *associations* are different from DTS *roles* and *associations* (the data modeling and knowledge representation community have historically used the names differently)

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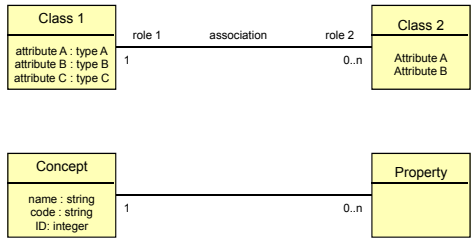
Background: Generic and Specific Class Diagrams



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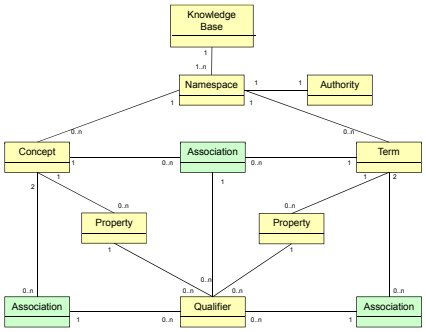
Simplified DTS Data Model



DTS KB Objects

- The DTS KB consists of instances of basic DTS Objects:

Namespaces	Properties
Concepts	Roles
Terms	Associations
Synonyms	Qualifiers

- Every KB Object has:
  - A string Name - Preferably meaningful, e.g., "Myocardial Infarction"
  - A string Code – Preferably meaningless, e.g., "C98765"
  - An integer Id - Preferably meaningless, e.g., 98765
- The Name, Code, and Id must be unique within their associated Namespace

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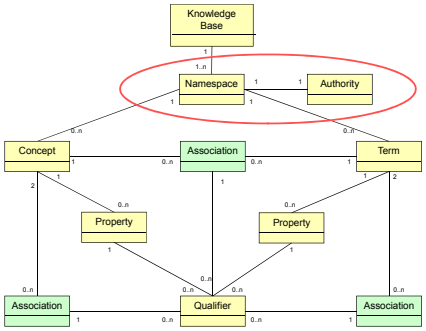
Simplified DTS Data Model



DTS KB Architecture

- Basic management unit is the *Namespace*
- A Namespace is a logical subdivision of the KB
- Defined as an authoritative point of view or content area (an Authority is the identifier for the supplier)
- Generally a single terminology
- Basic element of updates
- Basic element of security
  - Individual access privileges at Namespace level

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DTS Namespace Types

	Thesaurus	Ontylog	Extension
Modeling Tool for Content	DTS	TDE	DTS
Supports Apelon Supplied Content (Subscriptions)	Yes	Yes	No
Access Control	Read / Write Read Only (Subscription)	Read Only	Read / Write
Supports Local Content Modeling	Yes	No	Yes

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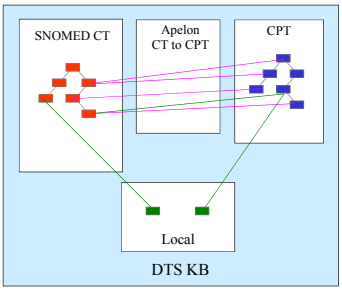
DTS KB Architecture

Subscription Namespaces

- Ontylog or Thesaurus
- Derived from industry sources
- Provided by Apelon
- "Read only" in DTS

Local Namespaces

- Thesaurus & Extension
- Customer-specific data
  - Concepts
  - Properties
  - Associations (mappings)
- Protected during updates



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Subscription Update Process

- Updates to standard (external) terminologies are provided by Apelon
- Updates are downloadable Change Sets
  - Differential/incremental updates
  - Apelon Common Data Format (CDF)
- Update and Change Set utilities available to licensees

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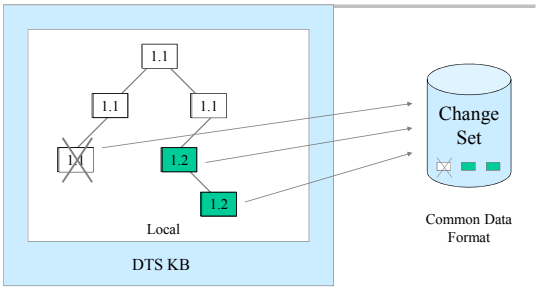
Change Set Creation



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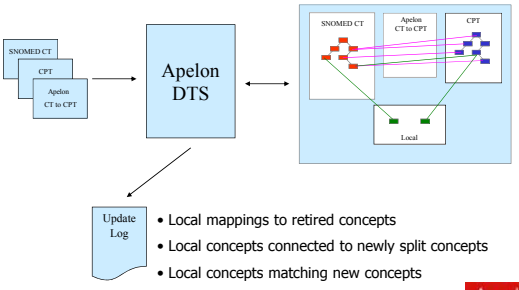
Subscription Update Process



- Local mappings to retired concepts
- Local concepts connected to newly split concepts
- Local concepts matching new concepts

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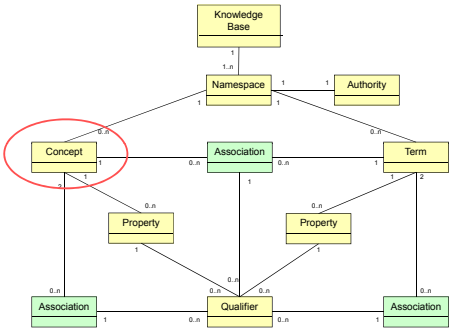
Simplified DTS Data Model



Concepts

- The foundational KB object is the *Concept*
- A *Concept* represents a unit of thought or meaning
- A *Concept* is "owned" by a specific *Namespace*
- *A Concept* should be unique within a *Namespace*
- Associated with a *Concept* are its *Attributes:*
  - *Properties*
  - *Synonyms*
  - *Roles*
  - *Associations*

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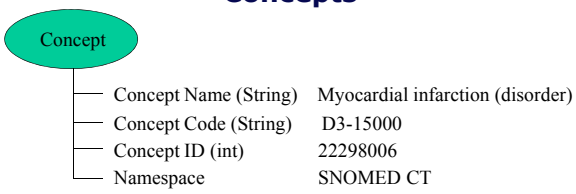
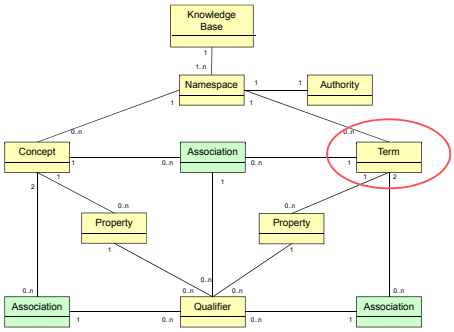
Concepts



Simplified DTS Data Model



Terms

- Terms are words or phrases (commonly used to refer to concepts)
- A Term is "owned" by a specific *Namespace*
- Terms can also have their own *Attributes*
  - *Properties*
  - *Associations*

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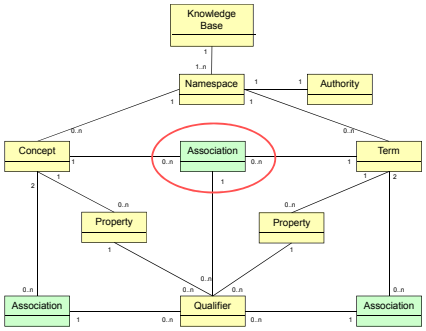
Simplified DTS Data Model



Synonyms

- A *Synonym* is a named relationship object between a *Concept* object and a *Term* object (a name)
- The relationship is an instance of an *Association Type*.
- *Synonym* triple: (*Synonym*) *Association Type, Term, Concept*
- The *Synonym Type, Term* and *Concept* can be from different Namespaces, aka "local Synonym"
- One (and only one) Synonym can be designated as the "Preferred Synonym"

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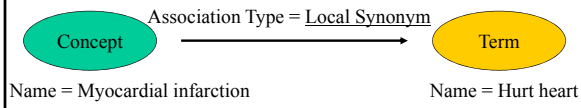
Synonyms (cont.)



- A *Term* can be associated with multiple *Concepts*.

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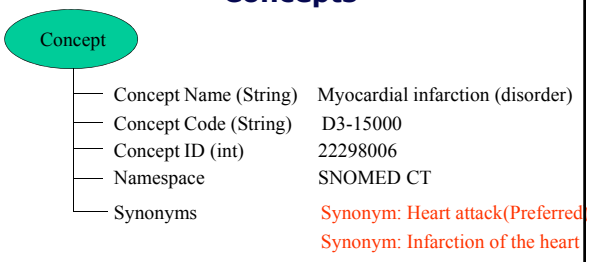
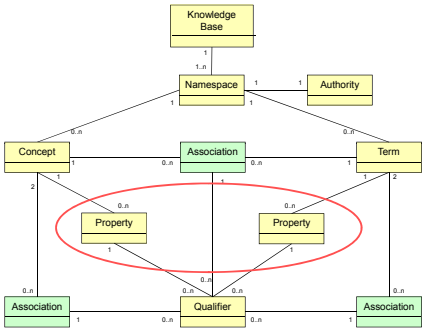
Concepts



Simplified DTS Data Model



Properties

- A *Property* is an object (triple) that has a name/value pair associated with a *Concept*
  - Name is a *DTS Property Type* (another KB object)
  - Value is a string value

    Myocardial Infarction → UMLS CUI: C0155626
- *Property Types* and *Properties* are "owned" by Namespaces that can be different from that of the Concept

  Local Property Type = Local Code
- *Properties* are often used to encode operational data:

  Myocardial Infarction → Specialty: Cardiology

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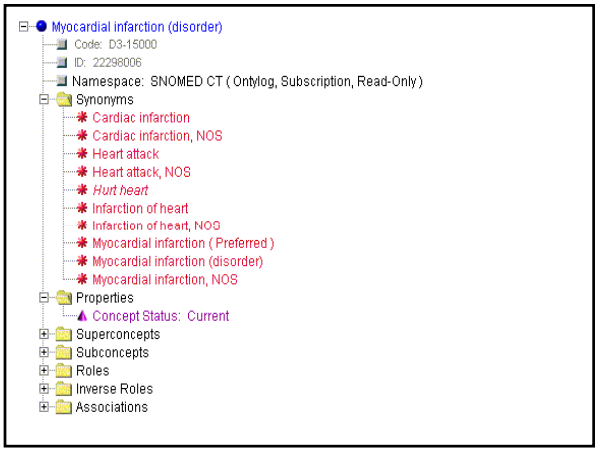
Concepts

Concept

Concept Name (String)	Myocardial infarction (disorder)
Concept Code (String)	D3-15000
Concept ID (int)	22298006
Namespace	SNOMED CT
Synonyms	Synonym: Heart attack Synonym: Infarction of the heart
Properties	Concept Status - Current UMLS CUI – C0155626 *Local Code – Z76523*



Ontylog Namespaces

- Ontylog Namespaces (SNOMED CT) are based on Description Logic (DL) Formalisms
- DL enables provably consistent hierarchical structures (among other features)
- This results in additions to the basic Object Model:
  - SuperConcepts (Parents)
  - Subconcepts (Children)
  - Roles
  - Kind

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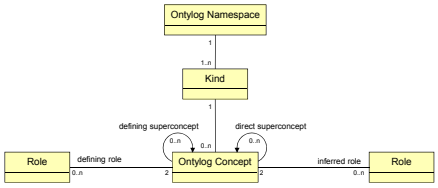
DL Aspects of DTS Data Model



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Parents and Children

- *Concepts* in Ontylog and Thesaurus *Namespaces* have hierarchical relationships
- More general *Concepts* are known as *Parents* or *Superconcepts*
- More specific *Concepts* are known as *Children* or *Subconcepts*
- *Ontylog Namespaces* use the *Superconcept* and *Subconcept* attributes
- *Thesaurus Namespaces* (usually) use a *Parent Of Concept Association*

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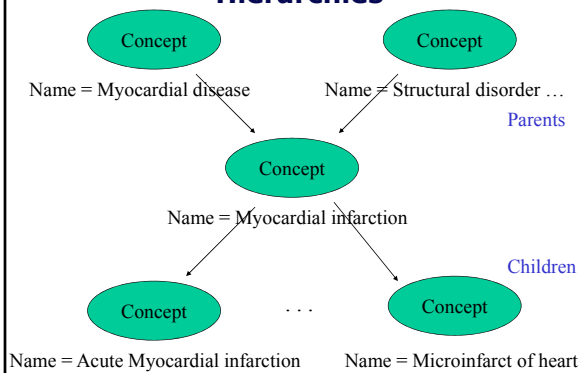
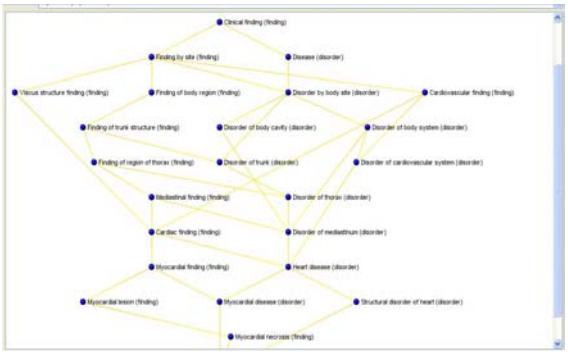
Hierarchies



- Myocardial infarction (disorder)
  - Code: D3-15000
  - ID: 22298006
  - Namespace: SNOMED CT (Ontylog, Subscription, Read-Only)
  - Synonyms
  - Properties
  - Superconcepts
    - Myocardial disease (disorder)
    - Structural disorder of heart (disorder)
  - Subconcepts
    - Acute myocardial infarction (disorder)
    - First myocardial infarction (disorder)
    - Microinfarct of heart (disorder)
    - Myocardial infarction with complication (disorder)
    - Old myocardial infarction (disorder)
    - Other specified anterior myocardial infarction (disorder)
    - Postoperative myocardial infarction (disorder)
    - Silent myocardial infarction (disorder)
    - Subsequent myocardial infarction (disorder)
    - True posterior wall infarction (disorder)
  - Roles
  - Inverse Roles
  - Associations

An Ancestor Tree



Relationships

- Relationship *Attributes* have a relationship *Type* and connect one *Concept* to another *Concept*
- The *Concepts* can be in the same or different *Namespaces*
- Types of Relationships include:
  - *Roles Types*
  - *Associations Types*

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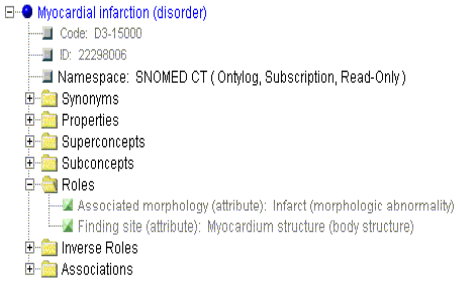
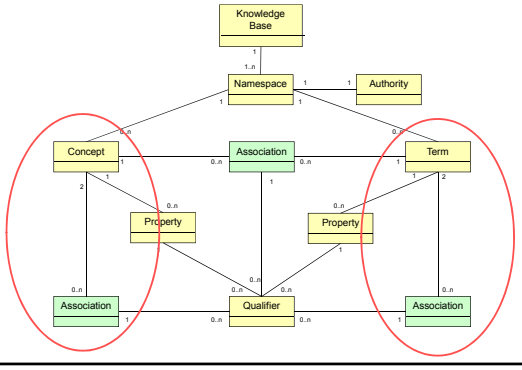
Roles

- *Roles* are relationships created by Apelon (or our customers) in Ontylog and Extension *Namespaces*
- *Roles* are used by Apelon's Description Logic classifier to build hierarchies
- *Roles* make explicit key relationships between *Concepts* in one *Namespace*:
  Myocardial Infarction has finding site *Myocardium*
- An instance of a *Role* has a *Role Type* (finding site) and a *from* and *to Concept*
- New *Role Types as well as Role* instances can be created in Extension *Namespaces (as of 3.5)*



Simplified DTS Data Model



Associations

- *Associations* are general relationships between *Concepts (or Terms)*
- *Concepts* can be in the same or different *Namespaces*

  Myocardial infarction has onset *Gradual onset*
- An *Association* triple has an *Association Type* (has onset) and a *from* and *to Concept*
- *Associations* are commonly used for "mappings" (*Associations* connecting *Concepts* in two different *Namespaces* used to designate equivalence)

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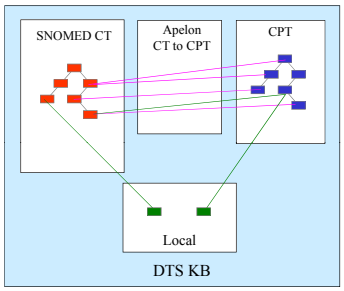
Associations



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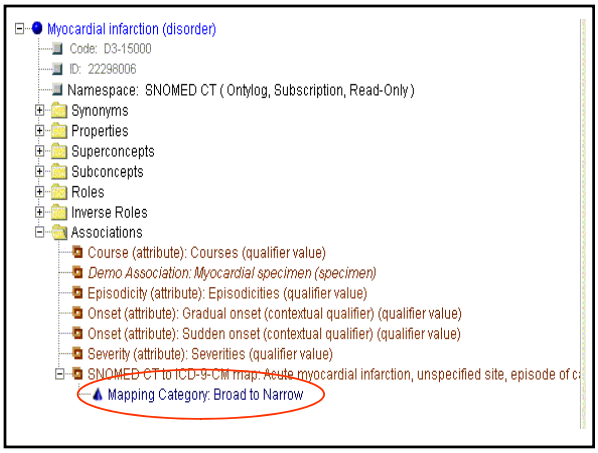
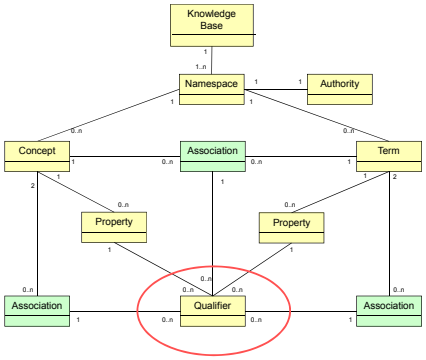


Simplified DTS Data Model



Qualifiers

- *Association* and *Property* instances can have one or more *Qualifiers* associated with them.
- *Qualifiers* are used to provide additional information on the *Attributes*:

  Date of Change: 08/26/2005

  Mapping Category: Broad to Narrow
- An instance of an *Qualifier* has an *Qualifier Type* (Mapping Category) and a string value ("Broad to Narrow")

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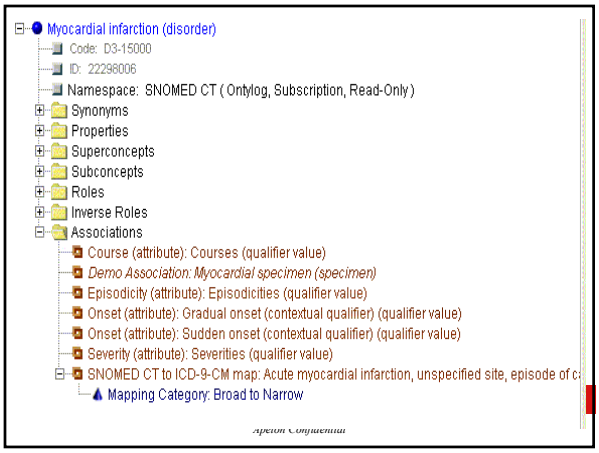

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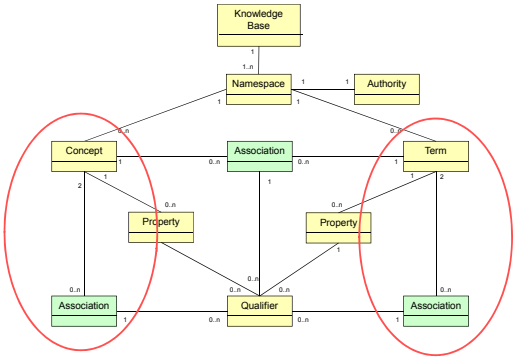
Simplified DTS Data Model



Inverse Relationships

- *Roles* and *Associations* have a preferred direction
- DTS provides capabilities for search and retrieval by the inverse of these relationships
- The Inverse Relationship can be given a different name or declared to be non-displayed:

  A treats *B* ↔ *B* is-treated-by *A*

  This assignment is made on the *Association/Role Type*

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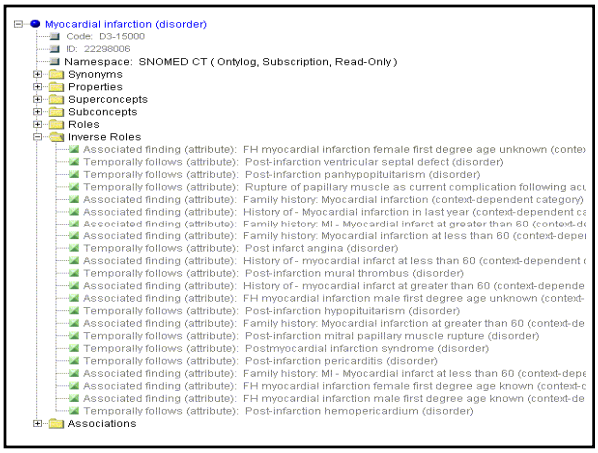
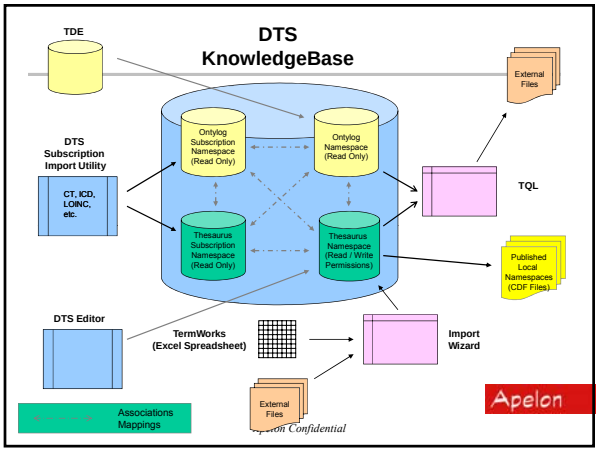


Object Model Summary

- Terminology data is structured in *Namespaces*
- A *Namespace* contains *Concepts* and associated *Attributes*
- Every *Concept* has a namespace-unique Name, Code and Id
- Subscription *Concepts* have pre-defined *Parents* and *Children*
- *Properties* are used to associate string data with *Concepts*
- *Roles* and *Associations* are *Concept*-to-*Concept* connections
- *Properties* and *Associations* can have *Qualifiers*



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Questions?

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Medical terminology in practice